a1 Cont

230 and interior to outer magnetic coil or permanent magnet 232. The magnetic material may contain specially shaped surfaces 264 to further correct the magnetic field for radial or azimuthal asymmetries in cooperation with coils 232 and 180 and interior magnetic structure 170.--

VERSION WITH MARKINGS TO SHOW CHANGES MADE

In the Specification:

Paragraph beginning on page 16, line 16 has been rewritten as follows:

--Figures 4a [through],4b, and 4c [is] are sections a-a, b-b, and c-c, respectively, through figure 4.--

Paragraph beginning on page 19, line 13 has been rewritten as follows:

--Figure 4 shows the present invention, which provides a convergent multiple beam klystron [140] 141 having a plurality of high current electron beams to permit construction of a multiple beam RF device of high power and high frequency. While the development of symmetric fields for radially symmetric devices is simplified by the intrinsic symmetry of the magnetic structures, this is not

the case for multiple gun, off-axis designs such as the present invention of figure 4. As known in the art, conventional electron guns are designed using advanced computational tools to model the electrostatic potential, magnet flux contours, and electron trajectories. Examples of these codes include Maxwell 2D® and Beam Optics Analysis (BOA®) from Ansoft Corporation, the three dimensional finite difference program MAFIA®, and the beam trajectory code XGUN®. These tools were used to model the present invention to insure that laminar electrons beams were generated suitable for a klystron or IOT RF circuit. It is clear to one skilled in the art that magnetic field design tools of this type are required for the optimization of specific structures for use in shaping a magnetic field in the present art of designing confining flow magnetic fields for use in electron beam devices. For the present invention, Maxwell 2D® and MAFIA® were used to design a magnetic configuration where lines of magnetic flux intersect each cathode perpendicular to the emitting surface with sufficient magnitude to guide the electrons through the cathode-anode region into the center of each beamlet's respective beam tunnel. Maxwell 2D® was also used to design the electrostatic geometry providing equipotential contours consistent with the desired operation. BOA® and XGUN® were used to model electron trajectories through the cathode-

anode region to insure that the desired performance was achieved.--

Paragraph beginning on page 20, line 23 has been rewritten as follows:

--Figures 4a, 4b, and 4c show cross section views of the present invention, and may be examined in conjunction with corresponding sections a-a, b-b, and c-c of figure 4. A plurality n of electron guns 230a, 230b,…230n is arranged circularly around a central axis Z 150. A reference plane R is perpendicular to the axis Z 150, and is used in the illustrations for section a-a, b-b, and c-c. Figures 4a-4c show a cross section view of a device[where n=7]. Each electron gun 230a..n is arranged circularly around the central axis Z and produces a beamlet which initially focuses to a minimum diameter 106a..n, as described earlier in figure 2. As is clear to one skilled in the art, other non-circular and irregular inter-gun spacings can be used, but the regular spacings and circular arrangement is shown for clarity in the drawings. Each beamlet from each electron gun 230a..n travels through its own beam tunnel 156a..n along a beam tunnel axis 152a..n to a collector 112a..n. Each beamlet travels in its respective beam tunnel 152a..g which has a conductive inner surface 173, and the

beam tunnel comprises drift tubes 133, 135, 137, and 139, and a series of resonant cavities 172, 174, 176 formed by drift tube gaps, and shown in figure 4-1 detail. These cavities are for the introduction of RF power, additional modulation of the electron beamlets, and the extraction of RF power, as before. The coaxial magnetic flux field generator [131] 130 comprises a coil wound around the axis 150, which produces a generally uniform flux field 132 aligned with the central axis 150, as before. The resonators are shown as 172, 174, 176 comprise the annular ring resonators described, for example, in U.S. Patent No. 4,508,992 by Bohlen et al (items 1 and 2), incorporated herein by reference. A key feature of the embodiment shown in Fig. 4[a] is the presence of an iron structure 170 and electromagnetic coil or permanent magnet 180, located along the centerline of the device and positioned at the approximate location of the individual cathodes 102. The iron structure 170 and magnet 180 provide compensation for the radial asymmetry of the magnetic field at the location of the individual cathodes 102, as will be described later.--

Paragraph beginning on page 22, line 14 has been rewritten as follows:

--Figures 4a-4c shows the sections a-a, b-b, and c-c, respectively, which include beam tunnels 156a..n, and the inner surface 173 and outer surface 171 of resonators 174.--

Paragraph beginning on page 23, line 19 has been rewritten as follows:

--An embodiment of the magnetic circuit for the device of Fig. 4 is shown in Fig. 6a. A shell of magnetic iron 140 encloses magnetic coils 130 that generate the main magnetic field for the RF device. As is clear to one skilled in the art, it would be possible to substitute a self-magnetic structure such as a permanent magnet for the coil 130 with appropriate modifications to iron structure 140. Apertures 210 are placed in the end walls of the shell 140 to allow passage of the electron beamlets and to allow magnetic flux to extend into the cathode-anode regions [106] 101 (not shown) of the electron guns to aid in beam focusing. An auxiliary electromagnet coil or permanent magnet 180 is located along the device centerline 220 and between the centerline and the individual electron guns 230. In addition magnetic material 170 is located along the device centerline 220 and between the electron guns 230 and the centerline 220. The magnetic iron 170 may include semicircular

extensions [172] 178 extending partially around the centerline of each individual beamlet 217 to reduce azimuthal asymmetries in the magnetic field at the location of the individual cathodes 102.--

Paragraph beginning on page 24, line 16 has been rewritten as follows:

--Figure 6b shows a section in the RZ coordinate system in the region between the magnetic polepiece end plate 140 and the electron gun emitter 102 where no correction is made to the magnetic field using coil 180 (not shown) or magnetic structure 170 (not shown). The figure plots contours of constant magnetic field 342 emanating through aperture 210 and extending to cathode 102. Certain structures from figure 6b are shown on figure 6c for clarity, including electron gun cathode 102 with electron emitting surface 101, shell 140, and beam tunnel axis 152. Note the asymmetry about the cathode centerline 152 and the variation of magnetic field across the emitting surface 101 of the cathode 102. Electrons emitted perpendicular to surface 101 will experience a magnetic field in which the direction of the magnetic field vector is different from the direction of electron motion, thereby imparting a transverse force on the

electron that will prevent proper transmission through the RF device.--

Paragraph beginning on page 25, line 17 has been rewritten as follows:

--An alternate embodiment is shown in figure 7, where an additional field shaping electromagnet coil 232 is located about the centerline of the device 220 but at a distance from the centerline so as to surround the cathodes for the individual beamlets. Certain structures from figure 6a are shown in figure 7 for clarity including Auxiliary coil 180, shell 140, coil 130, apertures 210, beamlets 217, iron structure 170, main magnetic field 132, and cutout 178. As is clear to one skilled in the art, and shown in figure 8, permanent magnets 240 and 242 could be substituted for coils 232 and 180 of figure 7 with no change in function. Field shaping electromagnet 232, or 180 or shaping magnet 240 or 242 would equivalently allow additional control of the magnetic field in the region of the electron beamlets. An alternate embodiment would include an iron shield partially enclosing coil 232 on the outer circumference and end to limit flux leakage into the environment and reduce

the power required for electromagnetic coils or the field strength for permanent magnets. Certain structures from figure 6a are shown in figure 8 for clarity including shell 140, coil 130, apertures 210, beamlets 217, main magnetic field 132, iron structure 170, central axis 220, and cutout 178. As is clear to one skilled in the art, there are many combinations of electromagnets or permanent magnets which could be used to satisfy the condition of creating a magnetic field which is perpendicular in gradient to the electron beam trajectory over all operating regions of the device.--

Paragraph beginning on page 26, line 14 has been rewritten as follows:

--Figure 9 shows the device of figure 4 wherein the iron 140 and magnetic coils [130] 131 are replaced by iron 250, 251, and permanent magnet 254, respectively. Certain structures from figure 4 are shown in figure 9 for clarity including electron guns 230a and 230e; beamlet focusing to minimum diameter 106a and 106e, central axis 150, iron structure 170, thermionic emitting surface 102a and 102e, resonators 172, 174, and 176, cathode centerline 152a and 152e; electron collector 112a and 112e; inner surface 173; and outer surface 171.--

Paragraph beginning on page 26, line 17 has been rewritten as follows:

--Figure 10 shows an alternate embodiment of the multiple beam device where additional magnetic material 260 is incorporated at a larger radius than the electron guns 230 and interior to outer magnetic coil or permanent magnet 232. The magnetic material may contain specially shaped surfaces 264 to further correct the magnetic field for radial or azimuthal asymmetries in cooperation with coils 232 and 180 and interior magnetic structure [172] <u>170</u>.--

With this amendment, this application is in condition for allowance. Examiner is advised that agent Chesavage may be reached by telephone at 650-619-5270, or via e-mail at patents@chesavage.com

Respectfully Submitted,

Jay Chesavage

Registration No. 39,137